Mixing and Entrainement in Convective Flows, Jets and Grid Turbulence

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Mixing and Entrainment in Convective Flows, Jets and Grid Turbulence

Смешивание и увлечения в
Конвективных течений и турбулентности Сетка

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INTRODUCTION

EXPERIMENTAL SETUPS/ MODELS:

CONVECTION, JETS, RAYLEIGH-TAYLOR

PIV, VORTICITY, ENTRAINMENT

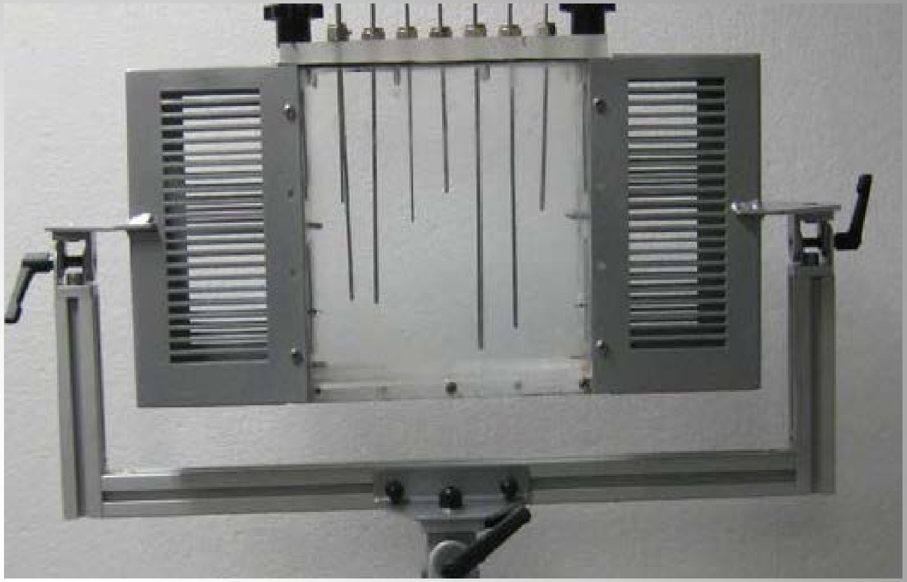
MULTIFRACTAL RESULTS

MIXING INTERMITTENCY and ESS

Введение
Эксперименты и модели конвективных течений
Сетка Турбулентность смешивания

Presentation of a Didactic Termoelectrive driven Convective flow generator

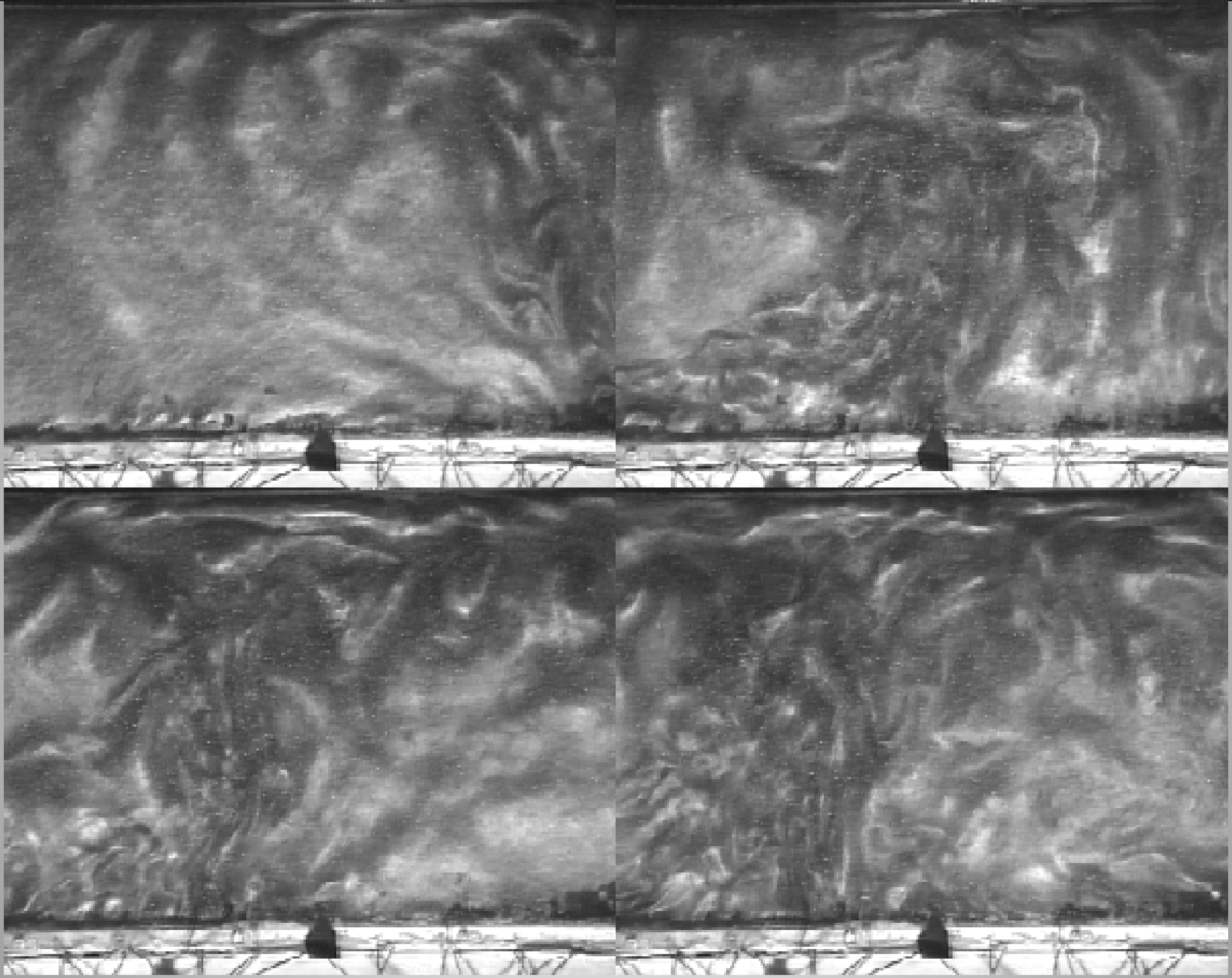
Презентация нового учебного термоэлектрических Конвективного потока генератор для визуализации



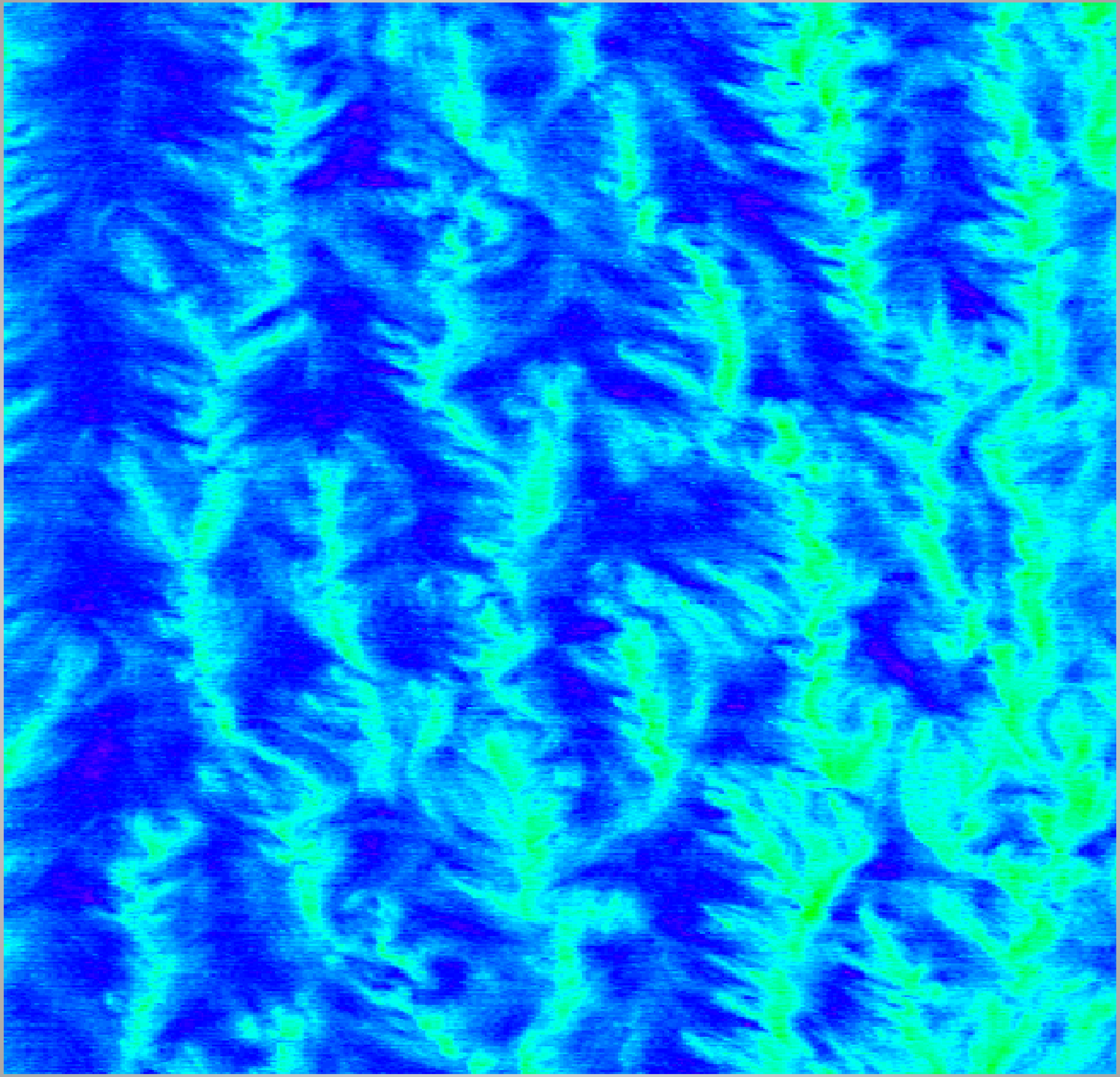
A Large Eddy Simulation model (LES) may be used to simulate the evolution of the rise of a bubble driven convective structure. This is an interesting problem to investigate the mixing process in the ocean surface layers when an injection of air or CO2 is used as an input of mechanical energy. Also taking into account the possible use of the Oceans as a CO2 sink. The model solves the Boussinesq equations in a two dimensional grid and is based in Rees(1987).

Local Diffusion and the topological structure of vorticity and velocity fields is measured in the transition from a homogeneous linearly stratified fluid to a cellular or layered structure by means of convective cooling and/or heating[1,2]. Patterns arise by setting up a convective flow generated by an array of Thermoelectric devices (Peltier/Seebeck cells) these are controlled by thermal PID generating a buoyant heat flux [2].

The experiments described here investigate high Prandtl number mixing using brine and fresh water in order to form density interfaces and low Prandtl number mixing with temperature gradients. The set of dimensionless parameters define conditions of numeric and small scale laboratory modelling of environmental flows. Fields of velocity, density and their gradients were computed and visualized [3,4]. When convective heating and cooling takes place the combination of internal waves and buoyant turbulence is much more complicated if the Rayleigh and Reynolds numbers are high in order to study entrainment and mixing.



- Heating-Cooling Breeze Model . Redondo et al(1995)



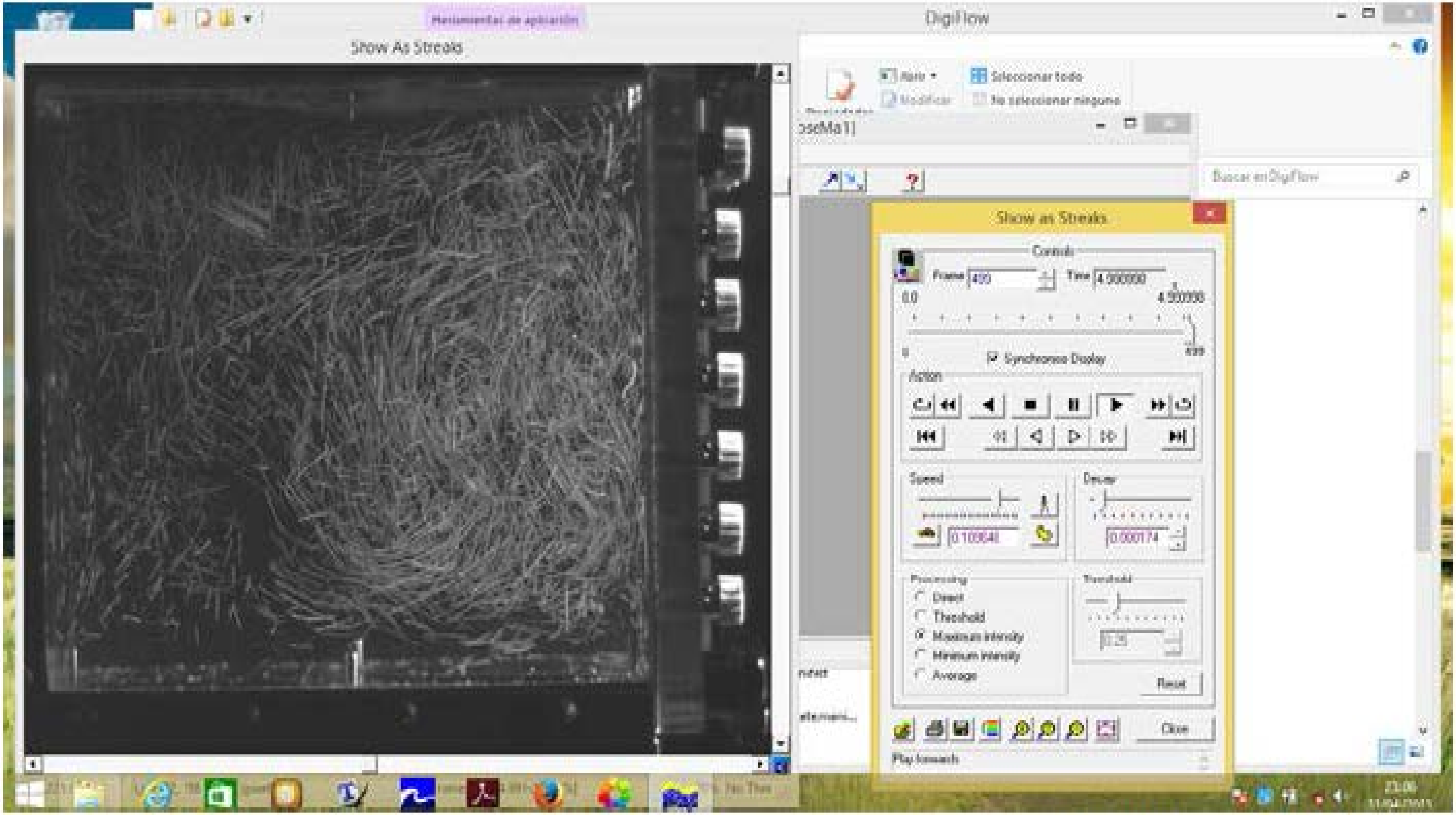
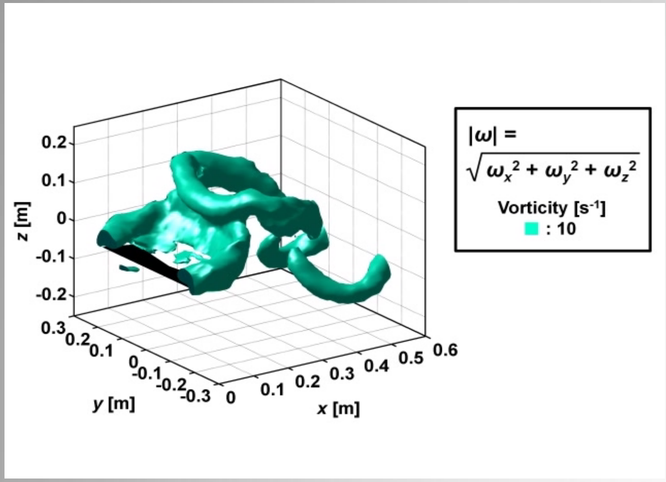
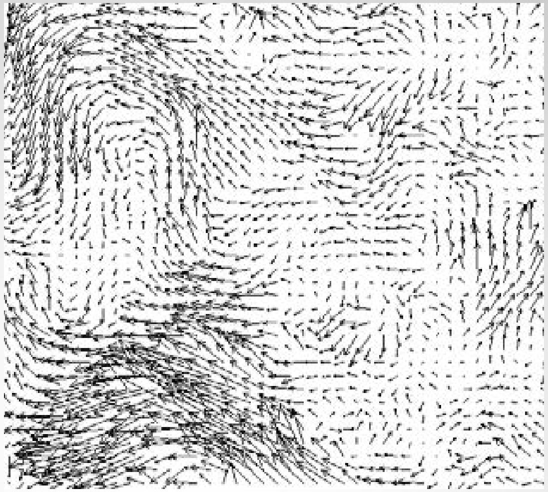
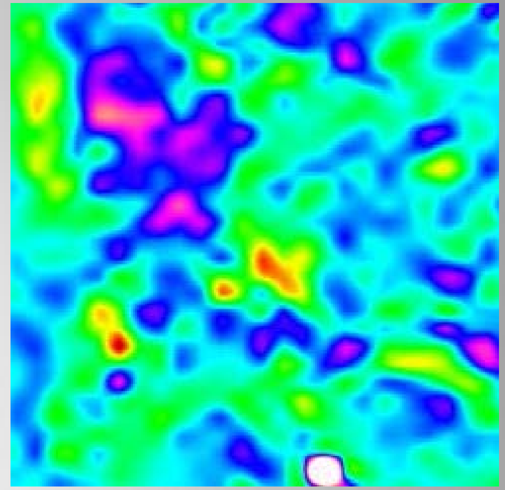


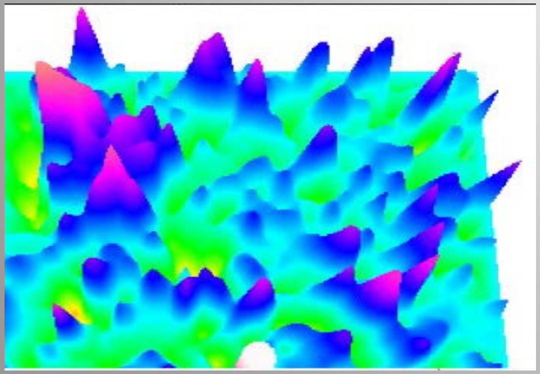
Fig. 6. Description of the DigImage program showing streaks from PT-PIV In the Thermoelectric (TCDD),showing different convective patterns



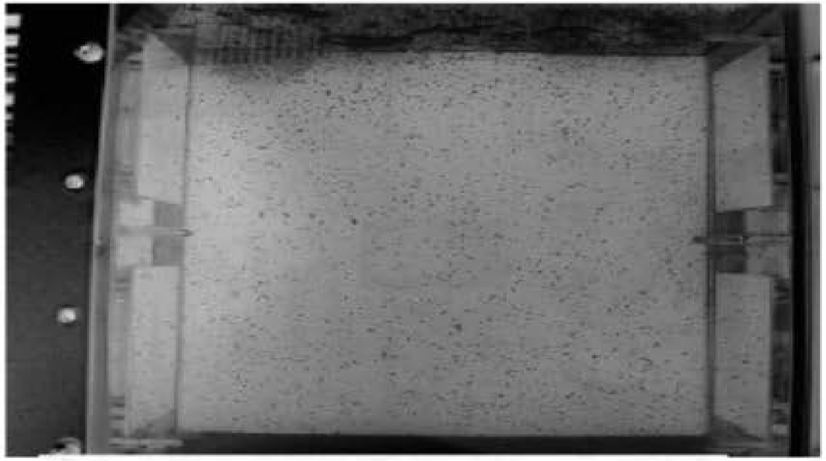




Термоэлектрический отопления и охлаждения
производит скорости и вихревых структур
используется для визуализации конвективных течений



Отслеживание частиц эксперименты
используются для сравнения
с моделями турбулентности



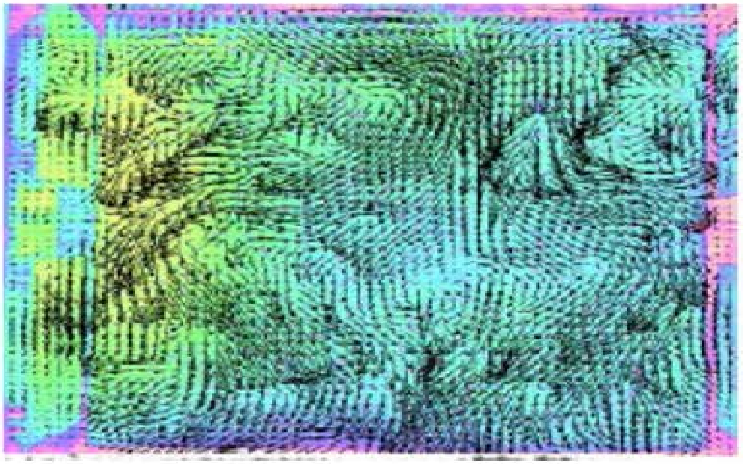
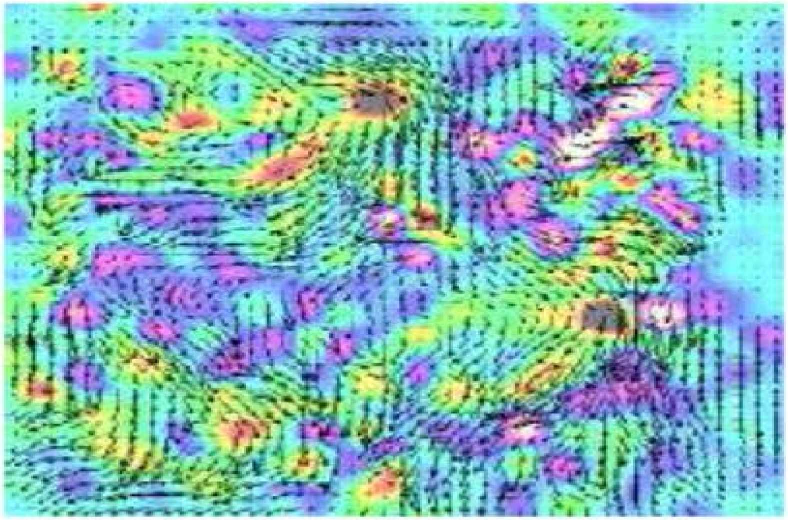


Fig. 7. Experiment with PIV on Pliolite 100 micron particles and vorticity-velocity visualization



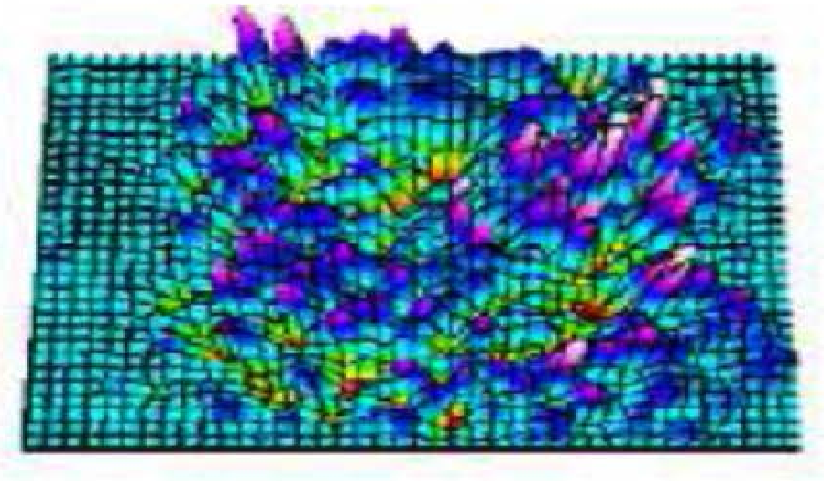
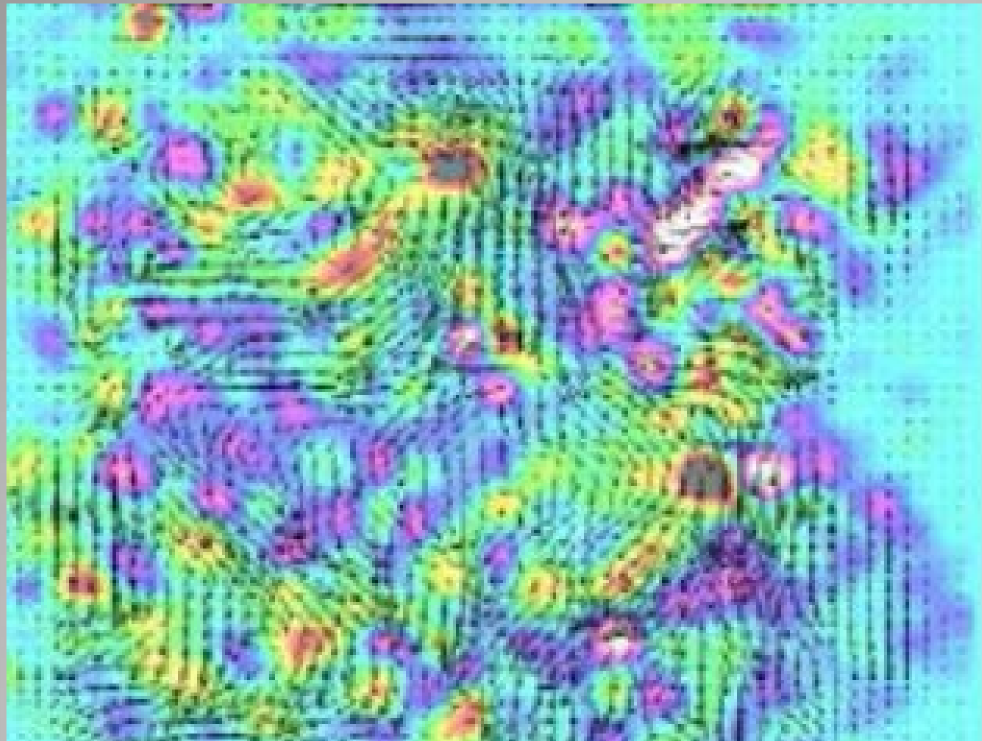
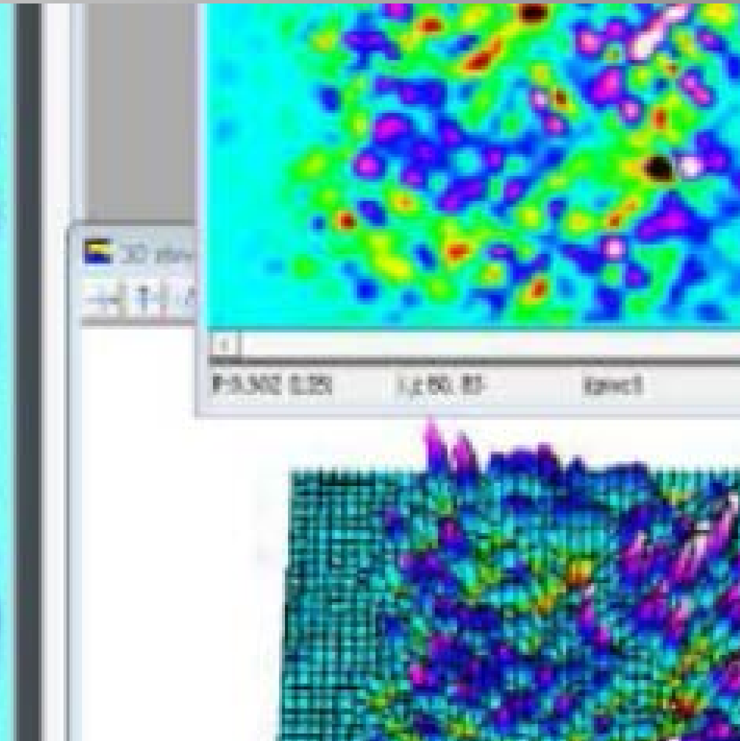


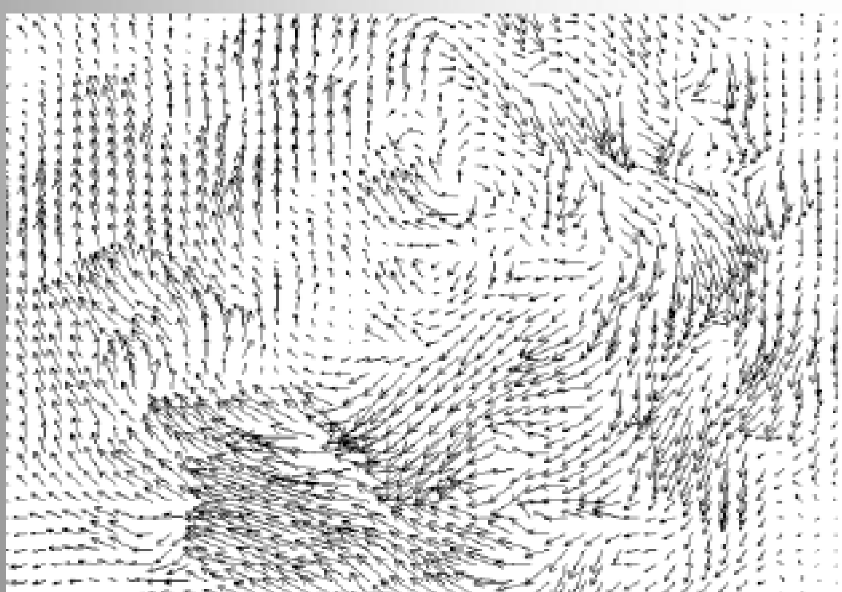
Fig. 8. Results with DigiFlow on PIV (vorticity-velocity visualization) (right)- 3D view.

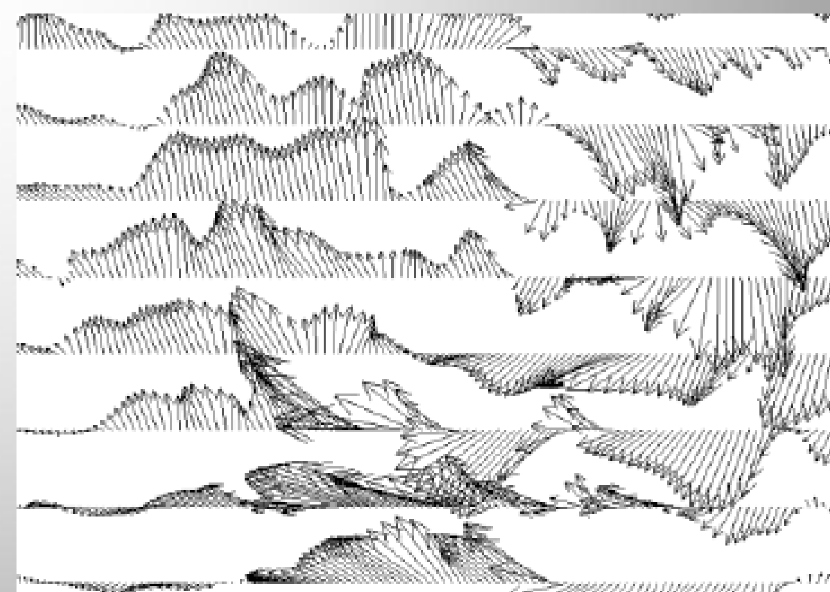
We show in figures 1 and 2 a thermoelectric driven heating and cooling experimental device also used to map the different transitions between 2 Dimensional convection in an enclosure and the 3 D complex flows. Thermoelectric coolers offer the potential to better control and enhance the cooling of electronic modules to regulate operating temperatures or to allow higher power. Thermoelectric coolers are limited by the maximum heat fluxes and have lower coefficient of performance (COP) but offer a wide range of boundary fluid control. Environmental and Engineering Fluid Mechanics laboratories at university or professional schools may incorporate student practical work in several of many fields that need understanding such as:

- ENVIRONMENTAL FLOWS: Convection in the Atmosphere; Thermal plumes in the ABL; Sea and Mountain Breezes; Inversion layers; Thermohaline convection; Thermal and Solutal Mixing; Diffusion; Turbulence scaling,...
- FLUID DYNAMICS AND HEAT TRANSFER: Natural Convection, Laminar and Turbulent Convection, Enclosed Flows, Bottom and Side wall Thermal Boundary layers. Rayleigh and Nusselt number evaluation. Turbulent correlation,…
- NUCLEAR, CIVIL AND INDUSTRIAL ENGINEERING: Ventilation, Nuclear Reactor Cooling, Thermal Stratification, Buoyant Mixing, Wall thermal correlations, Chemical Thermal Reactions,...









3. Description of the TCDD experiments.

Looking at the laboratory apparatus there are many different exa.mple of flows that may be set up, considering only the simplest 4 Peltier cell prototype, with two in opposing sides, by orienting the visualization largest plane of 20cm x 20cm we can either heat/cool both vertical sides or top and bottom. In each configuration, leaving aside all possible non straight angle configurations then the short list of Heating-Cooling-No Heat flux configurations are: HHCC, CCHH,HCHC,CHCH, which mean cooling at one side and heating the other side or vv, or Heating below at both Peltier cells and cooling above, or vv. Or other simpler velocity set ups like CCCC or HHHH, cooling everywere at both sides of heating at the four cells or you can even set up a more complex pattern such as HCCH or CHHC meaning that a checkers type convective pattern appears.

The laboratory experiments described with this process will be analysed and coupled to complex mixing and scalar or heat transport. The experiment might give some new insights on scaling thanks to the fractal methods described above.

The method of analysis used, may be either Particle Tracking (PT) or the so called Particle Image Velocimetry (PIV), or (CIV) Correlation Image Velocimetry. In order to be able to use this method, the flow must be seeded with particles. Furthermore a laser or strong parallel light for the illumination of the particles and a proper detection device has to be added to the set-up .For the analysis of the experiment there are basically two different ways of recording the generated flow: a series of shots with a very fast photo camera or a short video with a regular camcorder. Since we had both possibilities, they were compared. From a didactic point of view, the simplest method was to us. VisualDub program to divide a short video into snapshots, Then using DigiFlow or MatLab to perform C/PIV and using ImaCalc [20] for final processing. All programs are freely available [21-25]. The last option of recording the experiment was chosen. Most of the times.

The dissipation and intermittency may also be evaluated in time, from velocity and vorticity figures such as those shown in figure 9 where the procedure described in [35-39] is also useful together with the calculations of the fractal dimension described in section 2.

Figure 9 shows the instantaneous velocity and vorticity data $V(x,y,z,t)$ for a single vertical plane at the centre of the TCDD, if no 3D effects are dominant, different descriptors can be calculated per unit area of the base surface. If h is the fluid layer height and $r(z,t)$ is the vertical density profile at time t. For a velocity structure function series with fractal dimensions, in which the cascade is function of the structure function of order p, defined as: $S(dv)^p = \{/v(r,t)-v(r-z,t)/^p\}$. We may assume two types of contribution: to v proceeding from active eddies generated by the local wall heat sources ,but also due to the vorticity persistence and a geometrical intermittency factor , related to the number of dissipation voids that gives the volume factor occupied by eddies of vertical(buoyancy) generation with a higher intermittency exponent due to Malkus relation, with an exponent due to the experimental (dimensional analysis) fact that at large Reynolds number, then: $Nu \sim Ra^{1/3}$.

Several types of flows are visualized in complex turbulence and the *D*-dimensional fractal Dimensions and intermittency are compared with results from turbulent models

PERGAMON

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CONTINENTAL SHELF RESEARCH

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Comparison of sediment resuspension measurements in sheared and zero-mean turbulent flows

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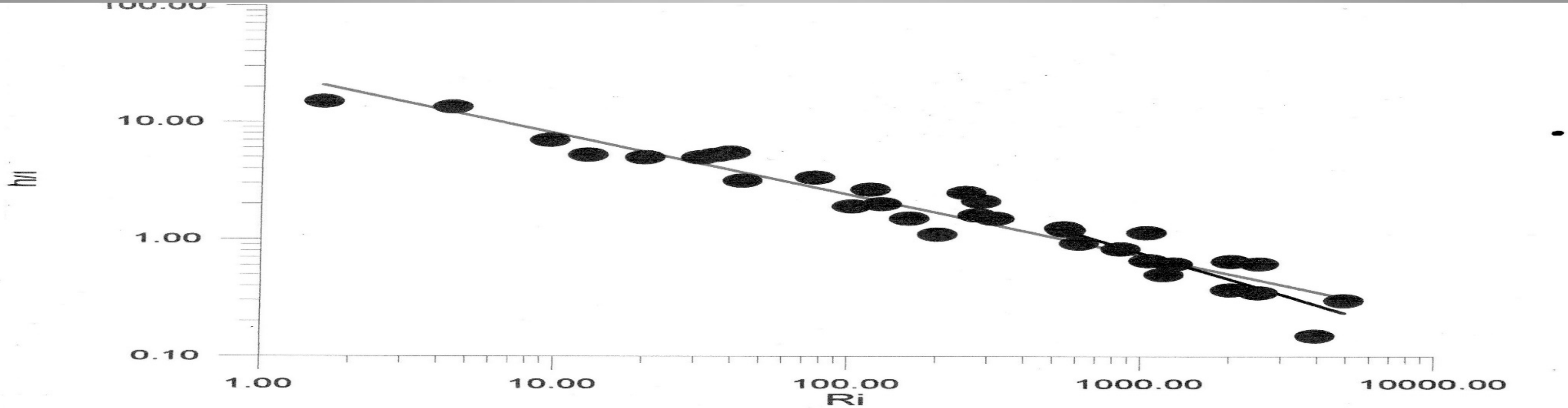
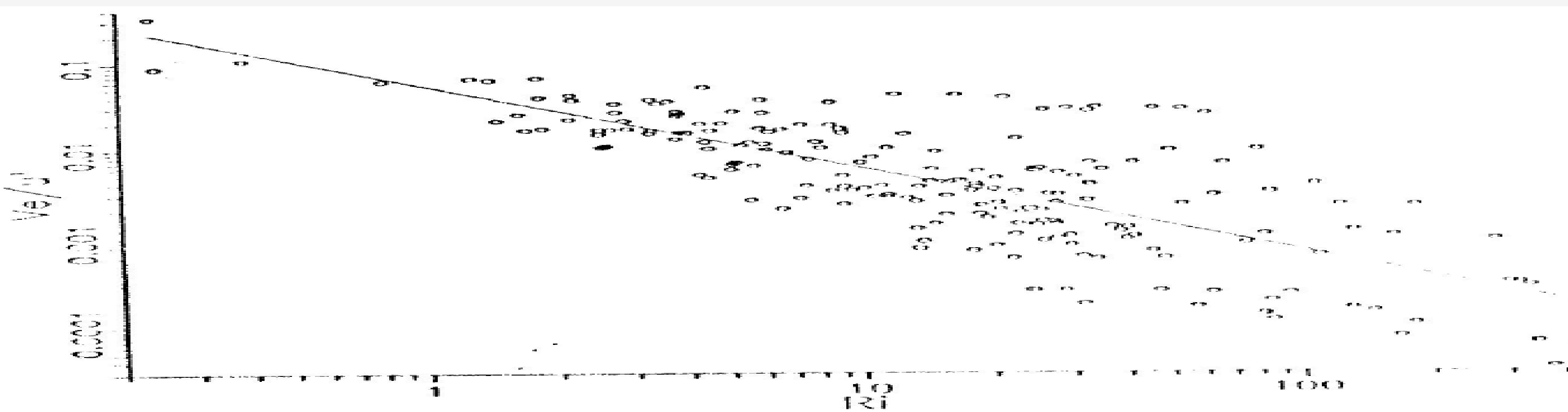


Увлечение сильно зависит от плавучести

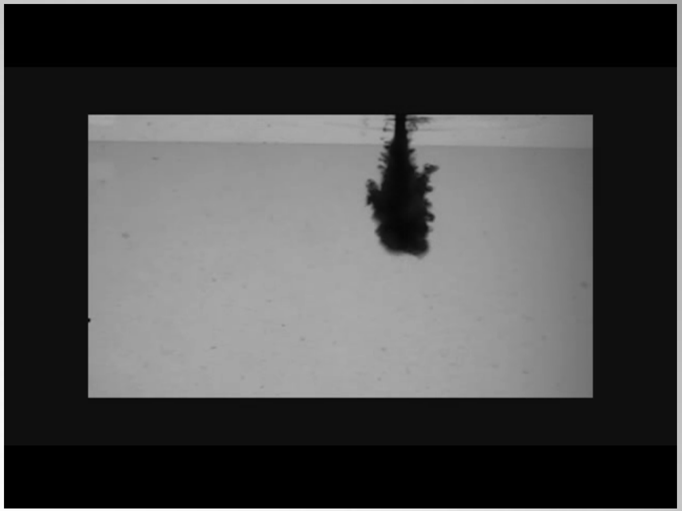
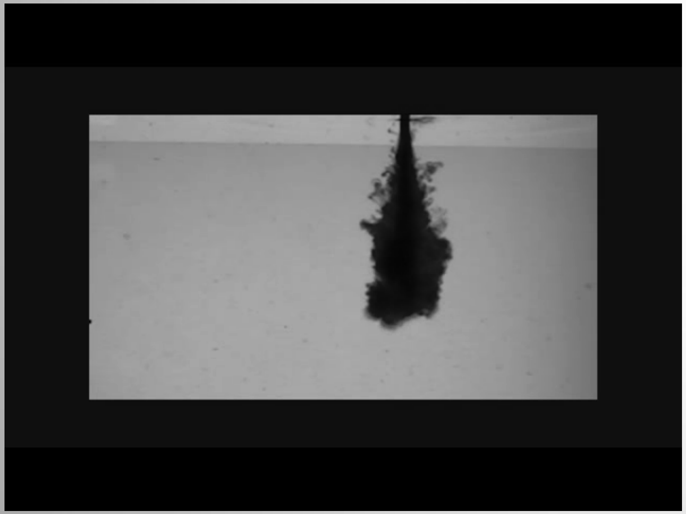
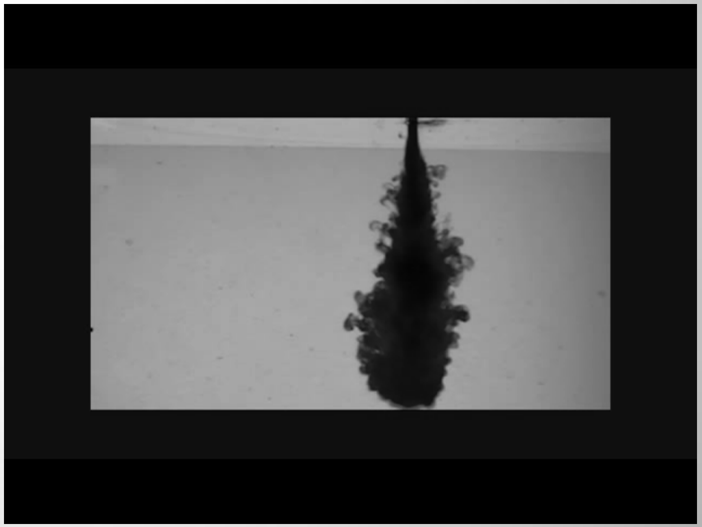
Эксперименты используются для измерения смешивания



In turbulent plumes we have observed that the entrainment coefficient is not a constant and varies in time. We have found that, at early times, the entrainment coefficient has an important dispersion and ranges between 0.26 and 0.9 for fixed H_o experiments and between 0.16 and 0.55 for fixed Atwood number experiments.

Close to the end of the experiment, the dispersion of the entrainment coefficient is not so great; it ranges between (0.17, 0.46) for fixed H_o experiments and between (0.37, 0.49) for fixed Atwood number experiments.

Отслеживание частиц эксперименты используются для сравнения с моделями турбулентности

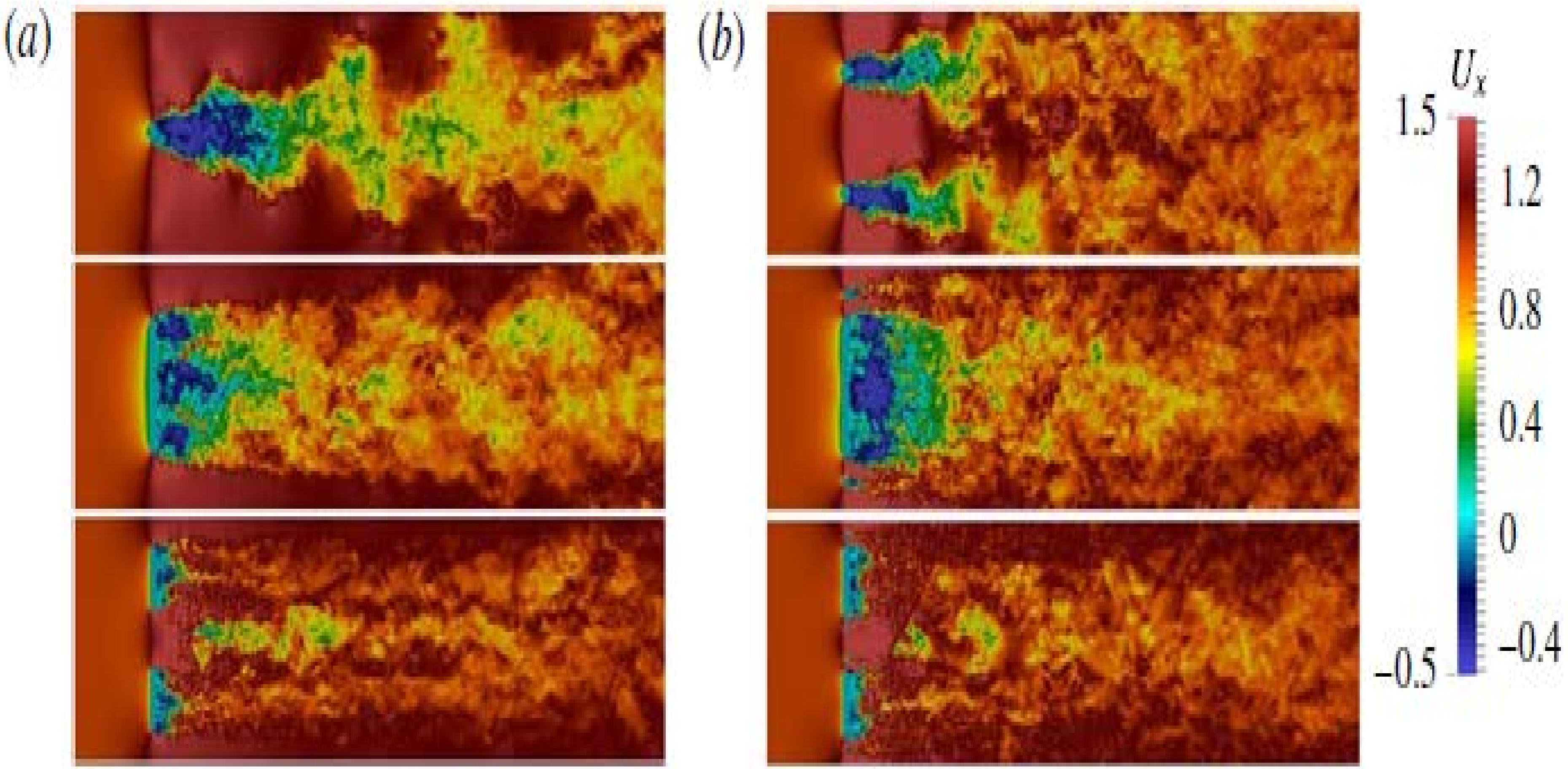
To account for this evolution, some authors proposed empirical or semi-empirical parametrizations allowing $\boldsymbol{\alpha}_E$ *to vary according to the ratio of the buoyancy and inertia forces:*

$$\alpha_E = \alpha_j - \left(\alpha_j - \alpha_p\right)\left(\frac{Fr_p}{Fr}\right)^2$$

where *Fr* is the Froude number of the jet with *R* the top-hat radius and Fr_p is the constant Froude number for a pure plume in a uniform environmental, α_j and α_p are arbitrary constant values of α_E for pure jets and pure plumes, respectively.

The values of α_E which best fit the data fall between the bounds formed by the values of α_E for pure jets and pure plumes in uniform environments (Carazzo et al., 2006) except at large distances from the source where α_E values are even smaller than those predicted for a pure jet.

Fractal grid wake (BSC)



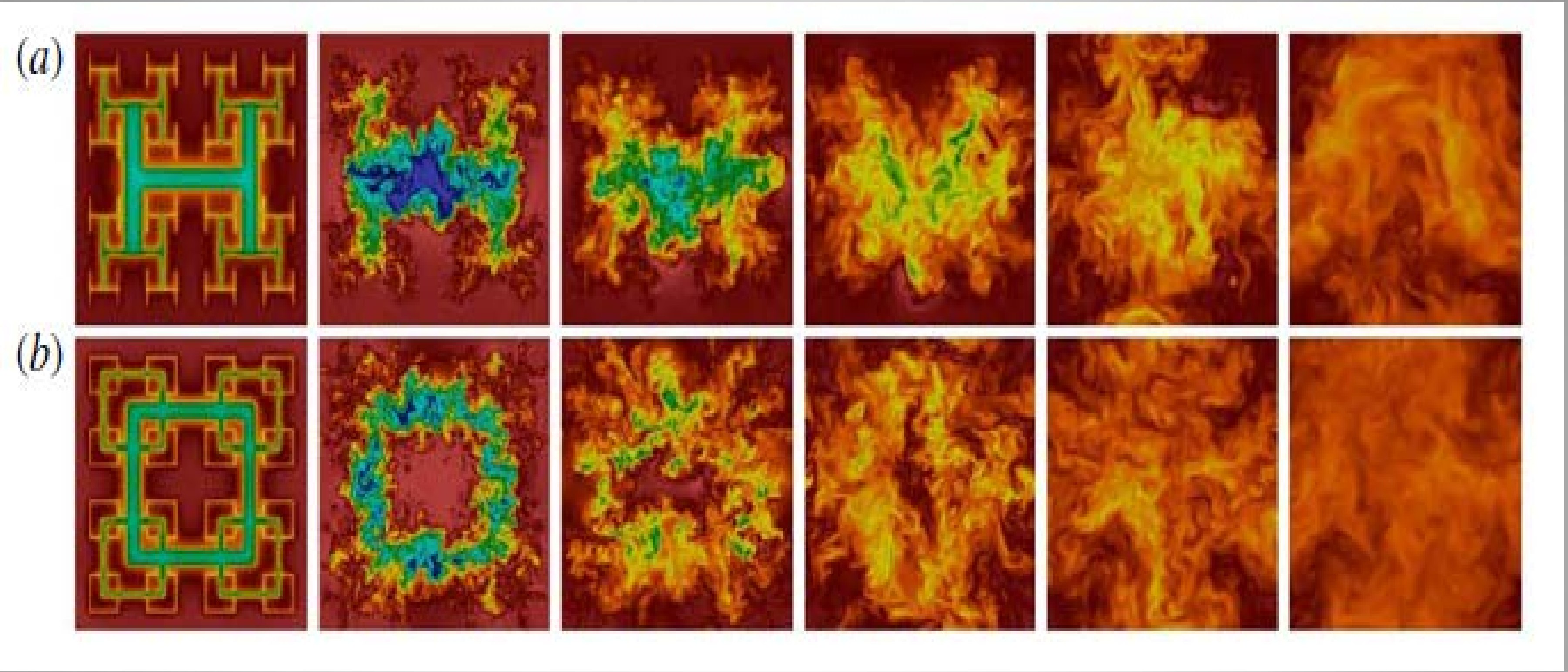
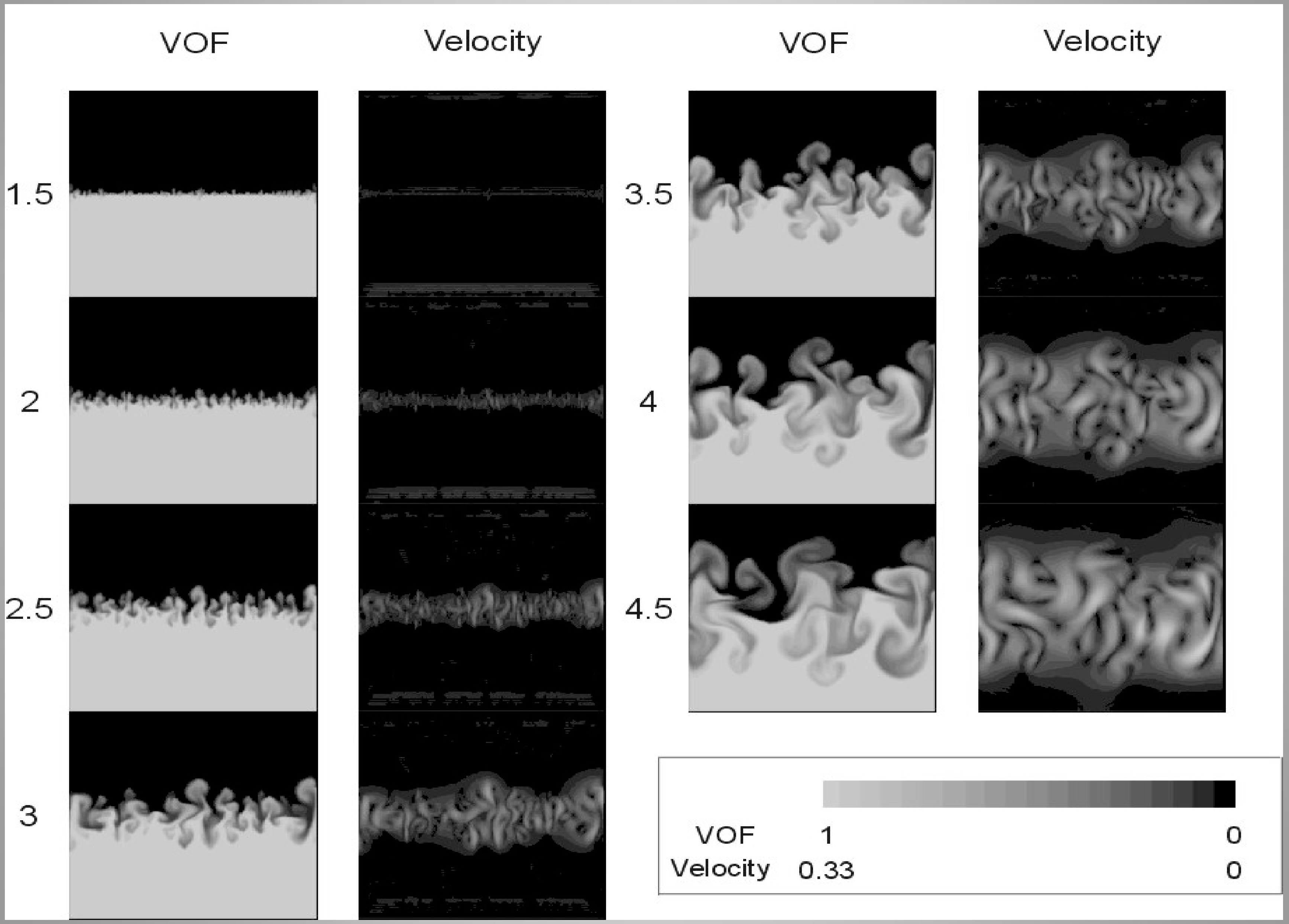


FIGURE 4. Instantaneous streamwise velocity component of the flow in the *(zy)* plane for the fractal I grid (*a*) and the fractal square grid (*b*) with three fractal iterations. The visualisations are at streamwise locations x/t_{min} = 0, 40, 80, 160, 320 and 640 from left to

right respectively (which correspond to x/M_{eff} = 0, 1.9, 3.81, 7.62, 15.24 and 30.48 for the I grid and x/M_{eff} = 0, 2.9, 5.84, 11.68, 23.36 and 46.7 for the square grid).



VOF
Velocity
VOF
Velocity
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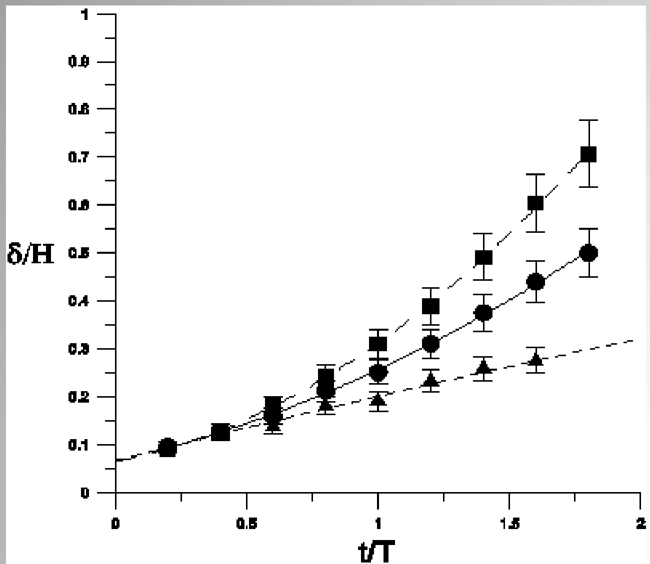
2
2.5
3
3.5
4
4.5
VOF 1 0
Velocity 0.33 0


δ/H
0
0.1
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0.9
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0.5
1
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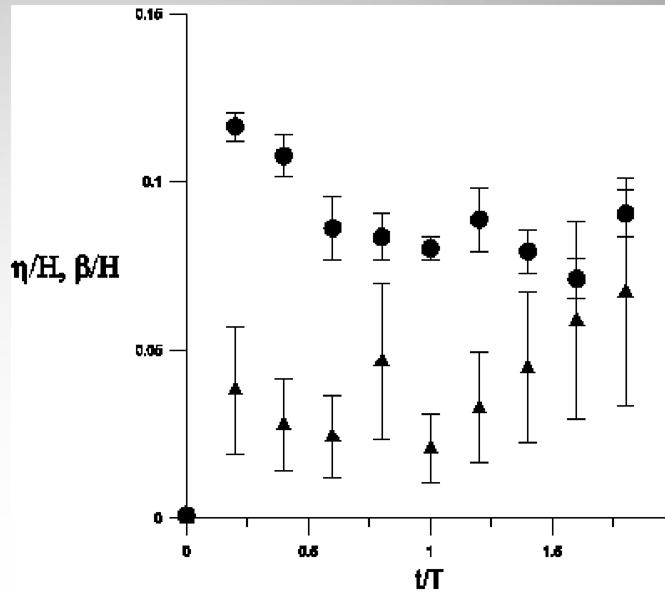
t/T


η/H, β/H
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0.1
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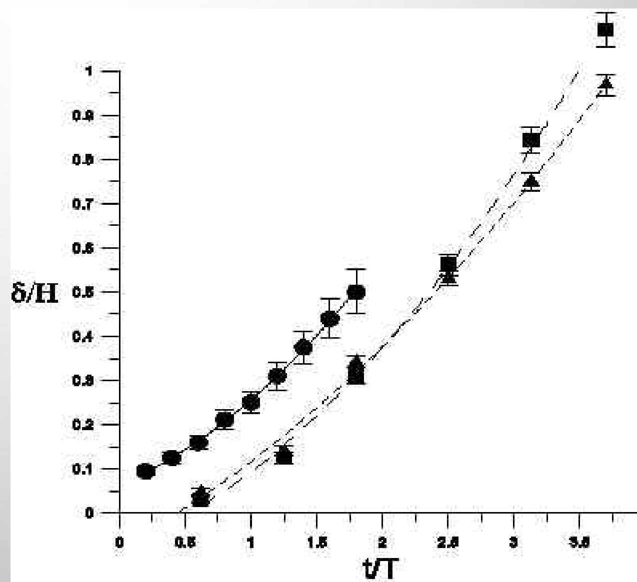
0
0.5
1
1.5
2
t/T


δ/H
0
0.1
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2
2.5
3
3.5
4
t/T

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Mixing Efficiency across Rayleigh-Taylor and Richtmeyer-Meshkov Fronts

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Bolgiano scale in confined Rayleigh–Taylor turbulence

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Simultaneous particle image velocimetry and synthetic schlieren measurements of an erupting thermal plume

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Explicit predictability and dispersion scaling exponents in fully developed turbulence

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Abstract

We apply a simple method to provide explicit expressions for different scaling exponents in intermittent fully developed turbulence, that before were only given through a Legendre transform. This includes predictability exponents for infinitesimal and non infinitesimal perturbations, Lagrangian velocity exponents, and dispersion exponents. We obtain also new results concerning inverse statistics corresponding to exit-time moments.

Key words: turbulence, intermittency, multifractal, scaling exponents
PACS: 47.27.-i, 47.53.+n, 47.27.Eq